JC05 Rec'd PCT/PTO 26 MAR 2002

FORM PTO-1390 (Modified) (REV 10-95) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER 1933 U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 10/089208
INTERNATIONAL APPLICATION NO. **PCT/DE 00/03342**	INTERNATIONAL FILING DATE **SEPTEMBER 26, 2000**	PRIORITY DATE CLAIMED **NOVEMBER 10, 1999**

TITLE OF INVENTION
METHOD FOR CORRELATING DISCRETE-TIME SIGNAL SEGMENTS

APPLICANT(S) FOR DO/EO/US
Marcus BENTHIN

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 18 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
    A **SECOND** or **SUBSEQUENT** preliminary amendment.
16. ☐ A substitute specification.
17. ☐ A change of power of attorney and/or address letter.
18. ☒ Certificate of Mailing by Express Mail
19. ☐ Other items or information:

ET706689019US.

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U.S. APPLICATION NO (IF KNOWN, SEE 37 CFR	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/089208	PCT/DE 00/03342	1933

				CALCULATIONS	PTO USE ONLY
20. The following fees are submitted:. **BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :** ☐ Search Report has been prepared by the EPO or JPO .... **$930.00** ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) .... **$720.00** ☐ No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) ...... **$790.00** ☒ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO .... **$1,070.00** ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) **$98.00**					
ENTER APPROPRIATE BASIC FEE AMOUNT =				**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).				**$0.00**	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	5 - 20 =	0	x $18.00	**$0.00**	
Independent claims	1 - 3 =	0	x $80.00	**$0.00**	
Multiple Dependent Claims **(check if applicable).**			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$890.00**	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable).**			☐	**$0.00**	
SUBTOTAL =				**$890.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$890.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☒	**$40.00**	
TOTAL FEES ENCLOSED =				**$930.00**	
				Amount to be: refunded	$
				charged	$

☐ A check in the amount of to cover the above fees is enclosed.

☒ Please charge my Deposit Account No. **19-4675** in the amount of **$930.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **19-4675** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

STRIKER, STRIKER & STENBY
103 EAST NECK ROAD
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SIGNATURE

MICHAEL J. STRIKER
NAME

27233
REGISTRATION NUMBER

MARCH 26, 2002
DATE

UNITED STATES PATENT AND TRADEMARK OFFICE

Examiner: Group: Attorney Docket # 1933

Applicant(s) : BENTHIN, M.

Serial No. :

Filed :

For : METHOD FOR CORRELATING DISCRETE-TIME SIGNAL SEGMENTS

SIMULTANEOUS AMENDMENT

March 25, 2002

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

S I R S:

Simultaneously with filing of the above identified application please amend the same as follows:

In the Claims:

Cancel all claims without prejudice.

Substitute the claims attached hereto.

REMARKS:

This Amendment is submitted simultaneously with filing of the above identified application.

With the present Amendment applicant has amended the claims so as to eliminate their multiple dependency.

Consideration and allowance of the present application is most respectfully requested.

Respectfully submitted,

Michael J. Striker
Attorney for Applicant(s)
Reg. No. 27233

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What is claimed is:

1. A method for correlating discrete-time signal segments, wherein a predetermined signal section in a signal is determined by means of the correlation, in particular for a signal transmission system, wherein the system having the known signal segment is sent from a transmitter to a receiver, and the position of the known signal segment in the signal is determined in the receiver by means of the correlation between the received signal and the known signal segment,
wherein the known signal segment is stored as erroned hierarchical sequence that is the sum of a hierarchical sequence and an error sequence; and
the correlation is formed as sum of a correlation between the received signal and the stored hierarchical sequence and a correlation between the signal and the stored error sequence.

2. The method according to Claim 1,

wherein the erroned hierarchical sequence $\underline{\tilde{h}}$ is depictable as follows by the hierarchical sequence $\underline{h}$ and the error sequence $\underline{h}_e$:

$$\tilde{h}(k) = \quad h(k) + h_e(k), \quad k = 0,\ldots, m-1$$

wherein m is a natural number and describes the length of the sequences $\underline{\tilde{h}}$, $\underline{h}$ and $\underline{h}_e$, and wherein the elements of the sequences $\underline{\tilde{h}}$ and $\underline{h}$ are from the range of values {$-\alpha$, + α} and the elements of $\underline{h}_e$ are from the range of values {-2 α, 0, +2 α}. α hereby represents any real or complex number.

3. The method according to Claim 2,

wherein the correlation *v(k)* of $\underline{\tilde{h}}$ having the signal *s(k)* is described by:

$$v(k) = \sum_{j=0}^{m-1} \tilde{h}(j) \cdot s(k+j) = \sum_{j=0}^{m-1} [h(j) + h_e(j)] \cdot s(k+j)$$

$$= \underbrace{\sum_{j=0}^{m-1} h(j) \cdot s(k+j)}_{u(k):=} + \underbrace{\sum_{j=0}^{m-1} h_e(j) \cdot s(k+j)}_{u_e(k):=}$$

wherein *u(k)* is the correlation between the signal *s(k)* and the stored hierarchical sequence, and $u_e(k)$ is the correlation between the signal *s(k)* and the stored error sequence.

4. The method according to Claim 1, [2, or 3], wherein the decomposition into the sum of a hierarchical sequence and an error sequence is carried out such that the error sequence contains as few elements as possible that are different from zero.

5. The method according to [one of the preceding claims] <u>Claim 1</u>, wherein it is used in a mobile telephone system.

What is claimed is:

1. A method for correlating discrete-time signal segments, wherein a predetermined signal section in a signal is determined by means of the correlation, in particular for a signal transmission system, wherein the system having the known signal segment is sent from a transmitter to a receiver, and the position of the known signal segment in the signal is determined in the receiver by means of the correlation between the received signal and the known signal segment,
wherein the known signal segment is stored as erroned hierarchical sequence that is the sum of a hierarchical sequence and an error sequence; and
the correlation is formed as sum of a correlation between the received signal and the stored hierarchical sequence and a correlation between the signal and the stored error sequence.

2. The method according to Claim 1,

wherein the erroned hierarchical sequence $\underline{\tilde{h}}$ is depictable as follows by the hierarchical sequence $\underline{h}$ and the error sequence $\underline{h}_e$:

$$\tilde{h}(k) = h(k) + h_e(k), \quad k = 0, \ldots, m-1$$

wherein m is a natural number and describes the length of the sequences $\underline{\tilde{h}}$, $\underline{h}$ and $\underline{h}_e$, and wherein the elements of the sequences $\underline{\tilde{h}}$ and $\underline{h}$ are from the range of values $\{-\alpha, +\alpha\}$ and the elements of $\underline{h}_e$ are from the range of values $\{-2\alpha, 0, +2\alpha\}$. α hereby represents any real or complex number.

3. The method according to Claim 2,

wherein the correlation *v(k)* of $\underline{\tilde{h}}$ having the signal *s(k)* is described by:

$$v(k) = \sum_{j=0}^{m-1} \tilde{h}(j) \cdot s(k+j) \quad = \quad \sum_{j=0}^{m-1} [h(j) + h_e(j)] \cdot s(k+j)$$

$$= \underbrace{\sum_{j=0}^{m-1} h(j) \cdot s(k+j)}_{u(k):=} + \underbrace{\sum_{j=0}^{m-1} h_e(j) \cdot s(k+j)}_{u_e(k):=}$$

wherein *u(k)* is the correlation between the signal *s(k)* and the stored hierarchical sequence, and $u_e(k)$ is the correlation between the signal *s(k)* and the stored error sequence.

4. The method according to Claim 1,
wherein the decomposition into the sum of a hierarchical sequence and an error sequence is carried out such that the error sequence contains as few elements as possible that are different from zero.

5. The method according to Claim 1,
wherein it is used in a mobile telephone system.

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METHOD FOR CORRELATING DISCRETE-TIME SIGNAL SEGMENTS

Related Art

The present invention relates to a method for correlating discrete-time signal segments, wherein a predetermined signal section in a signal is determined by means of the correlation, in particular for a signal transmission system, wherein the system having the known signal segment is sent from a transmitter to a receiver, and the position of the known signal segment in the signal is determined in the receiver by means of the correlation between the received signal and the known signal segment.

Although usable in any digital message transmission system, the present invention as well as its underlying problems will be explained in relation to UMTS (Universal Mobile Telephone Systems) systems.

To detect a known signal segment (also referred to hereinafter as “test signal”) in a received signal, the correlation of the test signal that is known and stored there with the received signal is usually carried out in the receiver.

This position determination of the test signal serves, for example, to determine the starting instant of the test signal within the received signal, i.e., for purposes of synchronization.

Of particular interest hereby are test signals that have good autocorrelation properties that are noted for a high autocorrelation coefficient in the relative time shift zero and, additionally, for low values for the autocorrelation to time shifts different from zero.

Moreover, these test signals should have a systematic structure that makes it possible to carry out the necessary correlations with the fewest arithmetic

operations possible. A special class of discrete-time test signals in this sense form “hierarchical codes” or sequences.

A hierarchical sequence $h(k)$ of the nth order is formed systematically out of n not necessarily different short sequences

$$\underline{h}_1 = (h_1(0), h_1(1), \ldots, h_1(m_1\text{-}1)), \quad \underline{h}_2 = (h_2(0), h_2(1), \ldots, h_2(m_2\text{-}1)),$$

$$\ldots, \underline{h}_n = (h_n(0), h_n(1), \ldots, h_n(m_n\text{-}1))$$

having elements $h_i(k) \in \{-1, +1\}$, according to the following construction scheme:

$$x_1(k) = h_1(k), \quad k = 0, \ldots, m_1\text{-}1, \qquad (1)$$

$$x_{i+1}(k) = h_{i+1}(k \operatorname{div} m_{i+1}) \cdot x_i(k \bmod m_i),$$

$$k = 0, \ldots, \left(\prod_{l=1}^{i+1} m_l\right) - 1, \quad i = 1, \ldots, n-1 \qquad (2)$$

$$h(k) = x_n(k), \quad k = 0, \ldots, \left(\prod_{l=1}^{n} m_l\right) - 1. \qquad (3)$$

The expense to correlate such a hierarchical sequence with another signal or another sequence can be reduced considerably in known fashion by means of a rapid correlation in multiple steps, as compared to a direct realization. Moreover, hierarchical sequences can be found that have good correlation properties and

are therefore well-suited in the sense mentioned initially as test signals for synchronization.

The mentioned procedure for the cost-efficient, rapid hierarchical correlation will be explained further hereinafter, because the method according to the invention described later is based on it. The received signal, with which the test signal is to be correlated in the receiver, is referred to as *s(k)*. Without restricting the generality, it suffices to consider hierarchical sequences of the 2nd order (i.e., n=2), because hierarchical sequences having more than two hierarchical levels are always formed successively out of two subsequences, according to the above equations. The correlation should be carried out for each instant k.

The correlation result *v(k)* is thereby as follows:

$$v(k)=\sum_{j=0}^{n-1}h(j)\cdot s(j+k) \quad = \quad \sum_{j=0}^{n-1}h_2\ (j\ div\ m_2)\cdot h_1\ (j \bmod m_1)\cdot s(k+j) \tag{4}$$

$$= \sum_{i=0}^{n_2-1}h_2(i)\cdot \underbrace{\sum_{j=0}^{n_1-1}h_1(j)\cdot s(k+i\cdot n_1+j)}_{v_1(k+i\cdot n_1):=} \ = \ \sum_{i=0}^{n_2-1}h_2(i)\cdot \sum_{j=0}^{n_1-1}v_1(k+i\cdot n_1) \tag{5}$$

Figure 2 illustrates the known hierarchical correlation procedure using the example of a hierarchical sequence of the 2nd order. The arithmetic steps are illustrated using lines.

The short subsequences are given by $\underline{h}_1$ = (+1, +1, -1, +1) and $\underline{h}_2$ = (+1, -1, +1, +1). The total sequence is therefore $\underline{h}$ = (+1, +1, -1, +1, -1, -1, +1, -1, +1, +1, -1,

+1, +1, +1, -1, +1). In the first step or the first subcorrelation step TK1, the subcorrelation $v_1(k)$ is determined. In the second step or the second subcorrelation step TK2, the searched-for correlation $v(k)$ is determined from this intermediate result. As time k continues, as indicated in Figure 2 using the bold lines, three known results can be referred back to in each case, and only one new calculation need be carried out in the subcorrelation step TK1, namely for the most recent ones, by the sampling of received signal values of the signal s(k).

Further correlation steps result accordingly for $n>2$ subsequences according to the same basic principle.

The problem underlying the present invention is basically that the known method is to be expanded to non-hierarchical sequences without the computer power becoming too great for the correlation.

Advantages of the Invention

The idea underlying the present invention according to Claim 1 is that it expands the known rapid multi-level correlation procedure for hierarchical sequences to include erroned hierarchical sequences.

An erroned hierarchical sequence $\underline{\tilde{h}}$ is to be described as a sequence, the construction of which is not immediately possible by means of decomposition into suitable subsequences, but a hierarchical sequence $\underline{h}$ can be found that is very similar to the sequence. The difference between $\underline{h}$ and $\underline{\tilde{h}}$ is described by a further sequence referred to hereinafter as error sequence $\underline{h}_e$. The decomposition of $\underline{\tilde{h}}$ into $\underline{h}$ and $\underline{h}_e$ should be selected such that the necessary

number of arithmetical operations for the correlation is reduced overall to the greatest extent possible.

In the method according to the invention, therefore, correcting expressions are also taken into consideration in addition to a hierarchical correlation to calculate the correlation $v(k)$. The method according to the invention is therefore to be referred to as a “corrected hierarchical correlation”.

The method according to the invention of corrected hierarchical correlation is usable on sequences that cannot be decomposed themselves directly, but for which a suitable representation as sum of a hierarchical sequence and an error sequence can be found.

The sequence presented further below in the exemplary embodiment is usable as subsequence for generating a hierarchical sequence for the Universal Mobile Telecommunication System (UMTS) for purposes of synchronization. The method according to the invention now allows for the further decomposition of this subsequence according to a corrected hierarchical structure, so that the necessary computer power for determining the correlation can be reduced by a further 40% approximately. Since the numerical expense for the synchronization of a mobile station with a base station makes up a significant portion of the baseband computer power in the mobile station overall, the method according to the invention is very useful in reducing the computer power required.

Reduced computer power in the baseband signal processing means, on the one hand, lower costs for the baseband hardware (lower clock rate, fewer logic gates, etc.). On the other hand, lower computer power also leads to reduced power input of the baseband hardware, so that extended speech or stand-by times can be made possible for mobile stations in particular that are operated using storage cells.

Advantageous further developments and improvements of the method indicated in Claim 1 are presented in the subclaims.

According to a preferred further development, the erroned hierarchical sequence $\underline{\tilde{h}}$ is representable as follows by the hierarchical sequence $\underline{h}$ and the error sequence $\underline{h}_e$:

$$\tilde{h}(k) = h(k) + h_e(k), \quad k = 0, \ldots, m-1 \tag{6}$$

wherein m is a natural number and describes the length of the sequences $\underline{\tilde{h}}$, $\underline{h}$ and $\underline{h}_e$, and wherein the elements of the sequences $\underline{\tilde{h}}$ and $\underline{h}$ are from the range of values {-1, +1 } and the elements of $\underline{h}_e$ are from the range of values {-2, 0, +2 }.

According to a further preferred further development, the correlation *v(k)* of $\underline{\tilde{h}}$ with the signal *s(k)* is described by:

$$v(k) = \sum_{j=0}^{m-1} \tilde{h}(j) \cdot s(k+j) = \sum_{j=0}^{m-1} [h(j) + h_e(j)] \cdot s(k+j) \tag{7}$$

$$= \underbrace{\sum_{j=0}^{m-1} h(j) \cdot s(k+j)}_{u(k):=} + \underbrace{\sum_{j=0}^{m-1} h_e(j) \cdot s(k+j)}_{u_e(k):=} \tag{8}$$

wherein $u(k)$ is the correlation between the signal $s(k)$ and the stored hierarchical sequence, and $u_e(k)$ is the correlation between the signal $s(k)$ and the stored error sequence.

The first addend $u(k)$ can be calculated directly using the rapid hierarchical correlation based on the hierarchical construction of $\underline{h}$. For the second addend $u_e(k)$, the further procedure depends on the structure of $\underline{h}_e$.

According to a further preferred further development, the decomposition into the sum of a hierarchical sequence and an error sequence is carried out in such a fashion that the error sequence contains elements that differ from zero as little as possible. Advantageously, a decomposition of $\tilde{\underline{h}}$ into $\underline{h}$ and $\underline{h}_e$ is such that $\underline{h}_e$ contains as few elements as possible that differ from zero.

For the case in which $\underline{h}_e$ contains, for example, only one element, $h_e(K) = ß$, different from zero ($ß \in \{-2, +2\}$), the calculation of $u_e(k)$ simplies to $u_e(k) = ß \cdot s(k + K)$, so that this follows:

$$v(k) = u(k) + ß \cdot s(k + K) \tag{9}$$

If there is more than one element different from zero, correspondingly more correction terms are to be taken into consideration. In the general case, a method for calculating correlation expressions can also be used again to calculate the expression $u_e(k)$.

According to a further preferred embodiment, the method is used in a mobile telephone system.

Brief Description of the Drawing

An exemplary embodiment of the invention is presented in the drawings and described in greater detail in the subsequent description.

Figure 1 shows an erroned hierarchical correlation procedure having a hierarchical sequence of the 2^{nd} order and a simple error sequence as exemplary embodiment of the present invention; and

Figure 2 shows the known hierarchical correlation procedure using the example of a hierarchical sequence of the 2^{nd} order.

Detailed Description of the Exemplary Embodiments

Referring to Figure 1, an exemplary embodiment of the method according to the invention corresponding to an erroned hierarchical correlation procedure having a hierarchical sequence of the 2^{nd} order and a simple error sequence is explained hereinafter.

The sequence presented in the exemplary embodiment has been proposed as a subsequence for generating a hierarchical sequence for the Universal Mobile Telecommunication System (UMTS) for purposes of synchronization.

The following Lindner sequence is considered (refer also to H.D. Lüke, *Korrelationssignale [Correlation Signals],* Springer Verlag, Berlin, Heidelberg, New York, 1992):

$$\underline{\tilde{h}} = (+1, +1, -1, +1, -1, -1, +1, -1, +1, +1, -1, +1, +1, +1, -1, +1),$$

which apparently cannot be decomposed directly into suitable hierarchical subsequences so that the known hierarchical correlation—favorable in terms of expense—can be used. As an alternative, however, it can be represented using a hierarchical sequence and an error sequence according to

$$\tilde{h}(k) = h(k) + h_e(k), \quad k = 0, \ldots, m-1 \tag{10}$$

with $\underline{h}$ = (+1, +1, -1, +1, -1, -1, +1, -1, +1, +1, -1, +1, +1, +1, -1, +1) and

$\underline{h}_e$ = (0, 0, 0, -2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0).

A hierarchical decomposition of $\underline{h}$ is given by the subsequences $\underline{h}_1$ = (+1, +1, -1, +1) and $\underline{h}_2$ = (+1, -1, +1, +1).

The correlation procedure overall can therefore take place advantageously using the method according to the invention by means of the corrected hierarchical correlation.

Figure 1 illustrates this procedure. In addition to the structure of the hierarchical correlation known from Figure 2, combinations of received signal *s(k)* to the result of the second subcorrelation step TK2 are to be seen that represent the correction terms in the form of values of the input signal weighted with –2.

A consideration of the expense for the entire correlation is carried out hereinafter. A direct realization of the correlation of the sequence $\underline{\tilde{h}}$ (the length of *m* elements) using a sequence of, in general, complex variables *s(k),* requires a number of *m* complex additions for each correlation value *v(k)* to be determined. With *m*=16, that is 16 complex additions in this example.

The splitting into the hierarchical sequence and the error sequence reduces this number significantly. Four complex additions per correlation value *v(k)* are required for the hierarchical correlation in the first step, and 4 are also required in the second step. In addition, there is the multiplication of the value *s(k + 3)* by the factor –2 and the addition of this correction value to the result of the hierarchical correlation, as indicated in Figure 1. If one takes into consideration the fact that the multiplication by 2 corresponds to a bit shift of one place and therefore requires a negligibly small amount of computer power as compared to a "real" multiplication, the only thing remaining, notably, is to incorporate the one additional complex addition by the correction value into the correlation result. Using the corrected hierarchical correlation, therefore, the entire correlation procedure requires 9 complex additions per correlation value *v(k)* as compared to the 16 complex additions mentioned hereinabove in the direct realization of the correlation. This represents a savings of a good 40%.

The method presented has a very high level of actuality with regard for the current worldwide intensive research and development activities of all manufacturers of mobile radio equipment involving third-generation mobile radio systems (UMTS, etc.).

Although the present invention was described hereinabove using a preferred exemplary embodiment, it is not limited to that. Instead, it is modifiable in multiple fashions.

In particular, the invention is not limited to UMTS (Universal Mobile Telephone Systems) systems. Instead, it is usable with any digital, discrete-time signal processing system.

What is claimed is:

1. A method for correlating discrete-time signal segments, wherein a predetermined signal section in a signal is determined by means of the correlation, in particular for a signal transmission system, wherein the system having the known signal segment is sent from a transmitter to a receiver, and the position of the known signal segment in the signal is determined in the receiver by means of the correlation between the received signal and the known signal segment,
wherein the known signal segment is stored as erroned hierarchical sequence that is the sum of a hierarchical sequence and an error sequence; and
the correlation is formed as sum of a correlation between the received signal and the stored hierarchical sequence and a correlation between the signal and the stored error sequence.

2. The method according to Claim 1,
wherein the erroned hierarchical sequence $\underline{\tilde{h}}$ is depictable as follows by the hierarchical sequence $\underline{h}$ and the error sequence $\underline{h}_e$:

$$\tilde{h}(k) = \quad h(k) + h_e(k), \quad k = 0,\dots, m-1$$

wherein m is a natural number and describes the length of the sequences $\underline{\tilde{h}}$, $\underline{h}$ and $\underline{h}_e$, and wherein the elements of the sequences $\underline{\tilde{h}}$ and $\underline{h}$ are from the range of values $\{-\alpha, +\alpha\}$ and the elements of $\underline{h}_e$ are from the range of values $\{-2\alpha, 0, +2\alpha\}$. α hereby represents any real or complex number.

3. The method according to Claim 2,

wherein the correlation *v(k)* of $\underset{-}{\tilde{h}}$ having the signal *s(k)* is described by:

$$v(k) = \sum_{j=0}^{m-1} \tilde{h}(j) \cdot s(k+j) \quad = \quad \sum_{j=0}^{m-1} [h(j) + h_e(j)] \cdot s(k+j)$$

$$= \underbrace{\sum_{j=0}^{m-1} h(j) \cdot s(k+j)}_{u(k):=} \quad + \quad \underbrace{\sum_{j=0}^{m-1} h_e(j) \cdot s(k+j)}_{u_e(k):=}$$

wherein *u(k)* is the correlation between the signal *s(k)* and the stored hierarchical sequence, and $u_e(k)$ is the correlation between the signal *s(k)* and the stored error sequence.

4. The method according to Claim 1, 2, or 3, wherein the decomposition into the sum of a hierarchical sequence and an error sequence is carried out such that the error sequence contains as few elements as possible that are different from zero.

5. The method according to one of the preceding claims, wherein it is used in a mobile telephone system.

Abstract of the Disclosure

The invention creates a method for correlating discrete-time signal segments, wherein a predetermined signal section in a signal is determined by means of the correlation, in particular for a signal transmission system, wherein the system having the known signal segment is sent from a transmitter to a receiver, and the position of the known signal segment in the signal is determined in the receiver by means of the correlation between the received signal and the known signal segment. The known signal segment is stored in the receiver as erroned hierarchical sequence that is the sum of a hierarchical sequence and an error sequence. The correlation is formed as sum of a correlation between the received signal and the stored hierarchical sequence and a correlation between the signal and the stored error sequence.

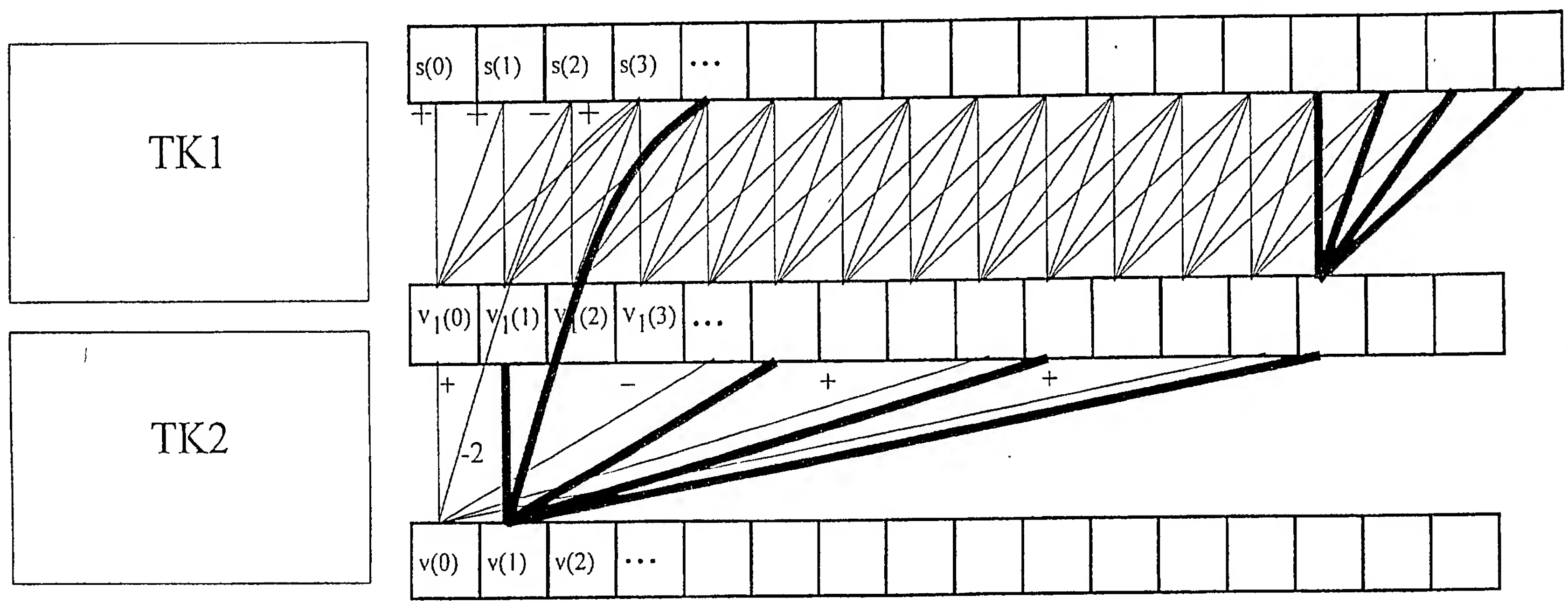

Fig. 1

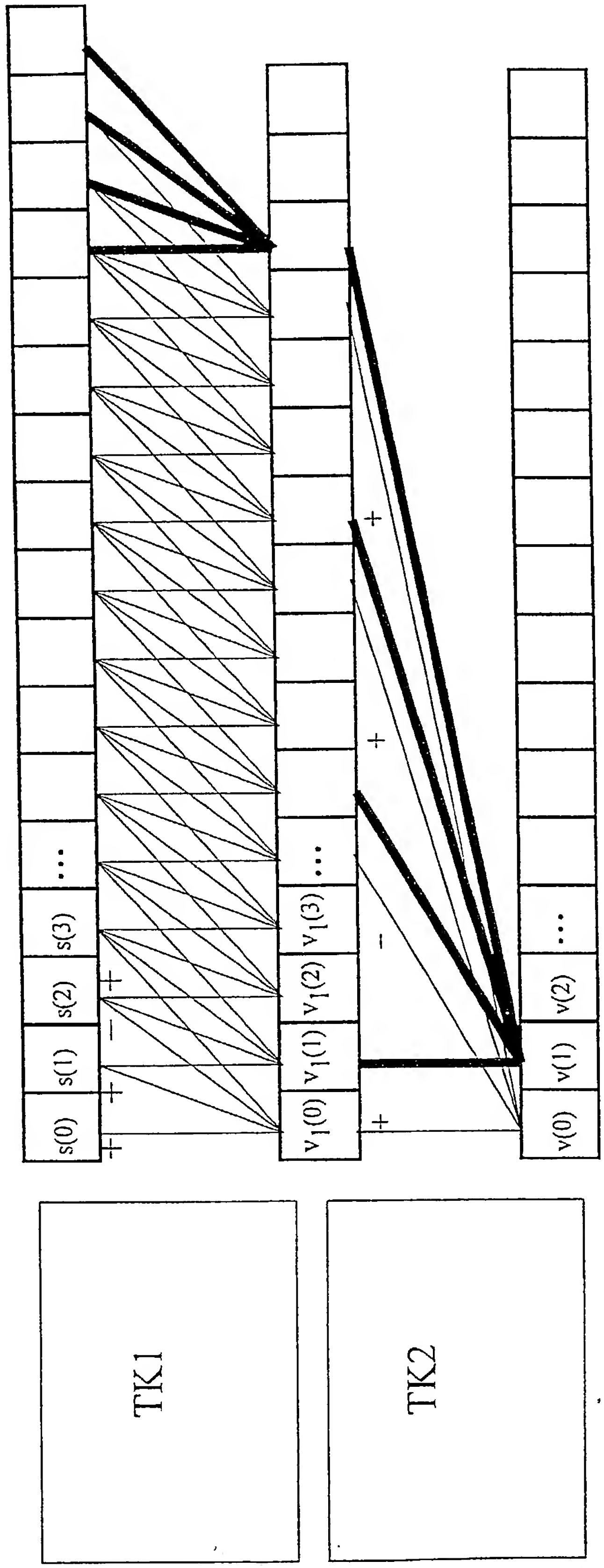

Fig. 2

DECLARATION AND POWER OF ATTORNEY FOR NATIONAL STAGE OF PCT PATENT APPLICATION

As a below-named inventor, I hereby declare that:

Marcus BENTHIN

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **METHOD FOR CORRELATING DISCRETE-TIME SIGNAL SEGMENTS** the specification of which was filed as PCT International Application number PCT/DE 00/03342 on September 26, 2000.

I hereby state that I believe the named inventor or inventors in this Declaration to be the original and first inventor or inventors of the subject matter which is claimed and for which a patent is sought.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365 (b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior foreign application(s):			Priority claimed:	
199 53 895.6	GERMANY	NOVEMBER 10, 1999	X	
(Number)	(Country)	(Date filed)	Yes	No
(Number)	(Country)	(Date filed)	Yes	No

As a named inventor, I hereby appoint the following attorney to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statement may jeopardize the validity of the application or any patent issued thereon.

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Full Name of Fifth Inventor:	Citizenship:	
Signature:	Date:	Residence and Full Postal Address:
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